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ABSTRACT

Technology assessment is the systematic identification, analysis, and evaluation of the real and potential impacts of technology on social, economic, environmental, and political systems and processes. In a highly industrialized society such as the United States, the interaction between technology and public policy is continual and complex. Federal executive agencies perform and fund research and development; they foster, subsidize, use, and regulate technological applications. Technology assessment has been advanced as a way of enabling decisionmakers to better understand and anticipate the societal impacts of technological developments. The purpose of the research reported in the present report was to carry out an empirical investigation of the quality of the Federal process for planning and evaluating technological programs. It was found that Federal executive agencies, have, within the last 5 to 10 years, improved and broadened the process through which they plan and evaluate technological projects and programs. However, Congress is demanding from public administrators more soundly grounded information about the possible consequences of governmental actions that decisionmaking on the national level might be even more improved. (HS)

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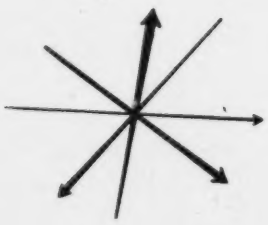
TECHNOLOGY AND PUBLIC POLICY

The Process of Technology Assessment in the Federal Government

Summary Report



Vary T. Coates

July, 1972

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TECHNOLOGY AND PUBLIC POLICY:
THE PROCESS OF TECHNOLOGY ASSESSMENT IN THE FEDERAL GOVERNMENT

INTRODUCTION

Technology assessment is the systematic identification, analysis, and evaluation of the real and potential impacts of technology on social, economic, environmental, and political systems and processes. It is concerned particularly with the second and third order impacts of technological developments; and with the unplanned or unintended consequences, whether beneficial or detrimental, which may result from the introduction of new technologies or from changes in the utilization of existing technologies. Technology assessment seeks to identify societal options and clarify the trade-offs which must be made; this approach is designed to provide an objective and neutral input to public decisionmaking and policy formulation with regard to science and technology. The analytical techniques of technology assessment may be integrated into the on-going process of planning, designing, and evaluating technological projects and programs, and may also provide an external review and evaluation of such projects and programs at any point in time.

In a highly industrialized society such as the United States, the interaction between technology and public policy is continual

and complex. Federal executive agencies perform and fund research and development; they foster, subsidize, use, and regulate technological applications. Political theorists of the nineteenth and twentieth centuries have grappled with the problem of the capacity of democratic systems to control and direct technological forces to serve societal needs and to protect public interests. The relationship between the State, the corporation, interest groups, and the individual is a central concern of modern political thought. On a more immediate level of concern, the interaction of social goals such as rising standards of living, equitable distribution of material goods, and maintenance of the physical environment has brought into question the viability of existing governmental institutions and their capability to deal with complex problems arising from socio-technological change.

Technology assessment has been advanced as a way of enabling decisionmakers to better understand and anticipate the societal impacts of technological developments. If technology assessment techniques can be developed and routinely integrated into legislative and administrative decisionmaking and public policy formulation, more rational choices can be made among alternative policies and actions. Anticipating problems and detrimental side-effects which result from any public action will permit their moderation or reduction.

In 1966, Representative Emilio Daddario, as chairman of the Subcommittee on Science, Research, and Development of the House Committee on Science and Astronautics, introduced the concept of

technology assessment, in proposing the establishment of an Office of Technology Assessment to serve the Congress. This occurred at a time of rising public alarm over alleged hazards to life and health resulting from contamination of the environment by the byproducts of chemical and industrial processes. Moreover, large public projects such as highway and airport development had occasioned numbers of public protests, demonstrations, and legal actions resulting in costly delays to many such projects. Growing hostility to technological programs aroused political pressures which intensified congressional suspicion of the process of planning and programming in executive agencies, and congressional resentment of the failure of executive agencies to provide Congress with adequate information about the impacts of governmental programs.

In this atmosphere the concept of technology assessment gained acceptance both among legislators and among professionals and academic specialists in science policy research. In the five years since Mr. Daddario first used the term "technology assessment," many academic and professional conferences and seminars have explored the concept of technology assessment, numerous papers have been presented at meetings of scientific societies, and scholarly journals and publications have carried treatments of the subject. The Subcommittee on Science, Research, and Development, chaired by Mr. Daddario and later by Representative John Davis, held several series of hearings and commissioned four reports on technology assessment, by the Library of Congress

and the National Academies of Sciences, Engineering, and Public Administration.

An underlying assumption in all of the discussion during this five years was that the existing process for planning and evaluating technological projects and programs within federal executive agencies is fragmented, diffuse, and inadequate in scope and depth. The purpose of the research reported in the present report was to carry out an empirical investigation of this assumption, and to provide a descriptive and analytical overview of the process of technology assessment as practiced in federal executive agencies in 1970 - 1971.

The objectives of this research were:

- To identify the loci at which technology and technological programs are assessed by federal executive agencies,
- To describe the process of technology assessment used by federal executive agencies,
- To identify the loci at which the same or similar technologies are assessed, and to determine where and how such overlapping assessments are or could be compared, weighed, or integrated,
- To identify gaps in the existing technology assessment process and to determine where and how such gaps might appropriately be filled,
- To describe typical technology assessments in terms of their initiation, purpose, methodology, research teams, costs, and results, and
- To provide a base of information for use in improving technology assessment in federal agencies and in constructing new assessment mechanisms if these are needed.

Departments and agencies of the Executive Branch were surveyed. Military and national security agencies and departments were excluded to limit the scope of the study. One hundred and forty offices within the civilian agencies were contacted, and their statutory charters, statements of responsibility, organization charts, publications, and research programs analyzed. On this basis, 86 offices were identified as having technological projects and programs.

One hundred and ten interviews were held with officials in the 86 offices. A series of questions, tested and refined through a preliminary set of ten interviews, were used to structure the interviews; however, the interviews were kept informal and questions worked into the conversation as unobstrusively as possible. (These questions appear in Appendix D of the full report.) The interviews lasted from one to two hours and were designed to elicit detailed description of the way in which projects and programs are selected, planned, and evaluated, and of the resources, personnel, and methodologies used in this process.

In the course of interviews, 97 examples of technology assessment and closely related studies were identified, and a further set of questions was used to develop information about their initiation, costs, research techniques, dissemination, and utilization. This analysis was an important final phase of the research.

The remainder of this summary volume presents the conclusions drawn from the research, with a series of recommendations for the

improvement of the technology assessment process in federal agencies. It addresses the following points:

- Who is doing technology assessment?
- The organization of technology assessments.
- Disciplines and techniques used in technology assessment.
- Analysis of a sample of technology assessment studies: initiation, disciplines, techniques, costs, scope, purpose, and utilization.
- Gaps and overlaps in governmental assessment of nine major technologies.
- Prerequisites for further improvement of technology assessment.
- Recommendations.

The full report of which this volume is a summary will appear in two parts -- the report itself, and a volume of appendices designed to serve as a reference volume for full substantiation of the report. The appendices include detailed descriptions of the offices studied, data on each of the 97 exemplary studies, a list of officials interviewed, and the questions used to structure the interviews.

The process through which decisions are made within bureaucratic structures is complex, highly convoluted, and poorly understood. It is anticipated that the information provided by this study will usefully contribute to attempts to understand, rationalize, and improve the decisionmaking process in the federal government.

SUMMARY AND CONCLUSIONS

Federal executive agencies have, within the last five to ten years, improved and broadened the process through which they plan and evaluate technological projects and programs. Whereas economic considerations, especially cost/benefit analysis of immediate planned effects, have been the mainstay of planning and programming, agencies are now taking into account a somewhat wider range of possible consequences of governmental actions and the exercise of federal responsibilities. Most are trying to take account of potential impacts which are derivative of the basic actions or programs, difficult to quantify, and not always satisfactorily translatable into monetary terms. The lack of generally accepted methods for integrating such considerations into administrative decisionmaking, and into the justification of agency programs, and the lack of sustained impetus and encouragement from the highest levels of the Executive Branch, cause this improvement to be slow and not uniform across agencies. But in many executive agencies, these new considerations -- encompassed in the concept of technology assessment -- are gaining general acceptance and systematic technology assessment processes and techniques are developing.

Congress is demanding from public administrators more soundly

grounded information about the possible consequences of governmental actions. The movement in the 1960's for increased public participation in decisionmaking, widespread alarms over alleged environmental hazards, and public protests over many public works projects created political pressures to which Congress reacted. Controversies culminating in court actions against highway, airport, and water resource projects caused costly delays in many projects and created new political obstacles to governmental objectives. Congressional concern crystallized in the National Environmental Policy Act of 1969, which has been the single most important factor in moving executive agencies to accept the idea of technology assessment. The proposed legislation to create an Office of Technology Assessment to serve the Congress (passed by the House in February 1972) underlines the continuing congressional dissatisfaction with Executive Branch methods of assessment and their demand for an independent accounting.

Who Is Doing Technology Assessment?

Eighty-six offices in federal executive agencies were identified as chiefly responsible for projects and programs of a technological nature. These offices were located in seven cabinet-level Departments, nine independent agencies, eight commissions, and four components of the Executive Office of the President. (Defense and security agencies were excluded.) In these 86 offices, extensive interviews showed that 24 percent

were concerned only with primary performance characteristics of technological systems and their direct dollar costs. Sixty-three percent perform or sponsor some technology assessments; the bulk of these are partial or narrow assessments which take into account some of the secondary consequences of technological applications, most often the secondary economic impacts or environmental impacts. The remaining 13 percent of the offices consistently perform or sponsor technology assessments and regard technology assessment as their major responsibility.

In the offices where it is performed or sponsored, technology assessment is viewed as support for agency planning and programming or as ancillary to substantive basic and applied research programs. It is most often found in offices bearing the title "Policy, Programs, and Evaluation" or an equivalent designation (25 percent) or offices solely responsible for research.

Thirty-five percent of offices sponsoring technology assessment reported that most or all such work was done in-house; the remainder preferred contract studies or a mix of in-house and contractor assessments. On 97 exemplary studies collected, 38 percent were performed in-house, 42 percent by contractors (15 percent by university researchers and 27 percent by other organizations), 9 percent by agency and contractors together, 4 percent by interagency groups, and the remaining 6 percent by panels of non-government experts convened by the agencies. Contractors performed or participated in all categories of studies but were

most heavily used for partial or narrow technology assessments (70 percent).

The Organization of Technology Assessments

The advantages of in-house assessment, which was preferred by 35 percent of the offices, were reported to be:

-- they had greater credibility for agency management,

-- they showed greater likelihood of producing institutional change in the agency,

-- individual assessors were protected from constituency pressure by their bureaucratic anonymity,

-- the data base remains available to the agency,

-- in-house expertise is developed and maintained,

-- the assessment activity can be flexibly scheduled in terms of time, resources, and workload.

The corresponding disadvantages of in-house assessments were perceived as:

-- the lack of a multidisciplinary staff in most offices,

-- a relative lack of external credibility,

-- the possibility of institutional bias,

-- the ease of suppression of assessments by administrators displeased by the findings or implications.

Most offices divide assessment activity between in-house staff and contractors depending on the size of the study, the availability of expertise, and the pressure of time and workload. A few officials preferred as a policy to have technology assessments performed by contractors rather than staff.

The advantages of technology assessments performed by contractors were reported as:

-- there is less institutional bias and greater objectivity,

-- they have greater external credibility,

-- more disciplines can be used than are present in most agency offices,

-- the regular work of the staff can proceed without interference.

In order to further enhance the opportunity for multidisciplinary assessment, there is a growing trend toward the use of consortia of research organizations.

Difficulties and disadvantages of having assessments done by contractors were reported:

-- there are severe difficulties of coordination and management when agency and contractor are geographically separated,

-- contractors tend to tell agencies what the agency wants to hear (as the contractor perceives it),

-- contractor reports can also be ignored or suppressed by agency management.

Officials showed a tendency to prefer independent research organizations over university-based groups, which were reported to have difficulty in organizing a management structure for large interdisciplinary research projects. When only one discipline or one or two researchers were to be involved, some officials preferred university research on the grounds of greater objectivity or greater prestige. Some university researchers who were contacted alleged that their findings were suppressed or misused by

agencies. University groups were also unable in some cases to compete for research contracts because of the rules of their institutions. Analysis of collected studies showed that costs per professional man-year were considerably lower for university groups than for independent organizations.

The advantages of using interagency mechanisms for performing assessments were reported to be:

-- they may have high level visibility and influence, depending on the level of personnel assigned to them,

-- they provide the opportunity for continuing monitoring and assessment,

-- they provide the opportunity to coordinate and rationalize policies of several agencies.

The off-setting disadvantages of interagency assessments are:

-- they are difficult to initiate because of the lack of a sponsoring authority,

-- they are avoided because of conflicting agency missions, responsibilities, and interests,

-- agency viewpoints and interests are seldom overridden, especially if the tasks of analysis are divided among the participating agencies.

"Blue-ribbon panels" of experts from outside of the government, especially from industry and universities, are sometimes convened to conduct assessments, especially those focused on societal problems related to technology. The advantages of using expert panels are:

-- they allow mobilization of expertise from many sources at low cost,

-- they tend to have high visibility, prestige, and influence

-- they offer the possibility of co-opting powerful segments of society for support of policies or decisions emerging from the assessment,

-- they allow representation of affected interests.

Expert panels also involve disadvantages:

-- there may be bias, or alleged bias, from institutional and occupational affiliations of the members,

-- they show a tendency toward conservatism in approach to problems,

-- the analysis may lack continuity, diligence, and consistency.

It is likely that maximum independence and comprehensiveness is gained when

-- the assessment is sponsored by a source not directly responsible for the program or project being assessed, such as the National Science Foundation or the Executive Office of the President, and

-- the assessment is performed by an independent research group or university group which values its reputation for objectivity as a chief stock-in-trade.

But unless the agency responsible for the program or project under assessment is fully prepared to accept the assessment and integrate the results into its own planning and programming process there will be little gain in terms of responsible decisionmaking.

Disciplines and Techniques Used in Technology Assessment

Engineers, economists, and physical scientists make up the bulk of the staff of offices which perform and sponsor technology assessments. Fifty-four percent of these offices had one or

more engineers engaged in technology assessment activity, 46 percent had economists, and 33 percent had physical scientists, while only 19 percent had one or more social scientists working on technology assessment. In most such offices, social scientists when present constituted only a small percentage of the staff. Analysis of specific studies, however, indicated that social scientists were somewhat more likely to be used in assessment studies than the above figures would indicate, because only 38 percent of the studies were done by agency staff; contractors more often included social scientists on their teams. On these research teams, however, the number of social scientists was again usually small compared to the number of team members claiming other disciplines.

Type of Assessment*	Percentage of research teams on which disciplines were represented by one or more team members:				
	Econ.	Engineer	Phy.Sci.	Biol.Sci.	Soc. Sci.
Wide-scope Assessments(9)	55%	33%	66%	33%	55%
Partial T.A.(40)	41	25	25	16	44
Problem-oriented T.A.(14)	30	20	40	10	10
Futures Research(17)	50	63	13	13	13

Most technology assessments rely heavily on the collation and judgmental analysis of existing information, along with field studies in the case of planned projects. Techniques from

*See definitions on page 18.

established disciplines and academic areas, such as cost/benefit analysis, surveys and interviews, and input-output tables, are often augmented by sophisticated techniques of systems analysis, operations research, and modeling and simulation. Wide-spread government acceptance of and use of these tools for analyzing complex problems is helping to persuade administrators that the complexities of social impact analysis are not beyond reach. Innovative techniques borrowed from futures research, such as Delphi, cross-support matrices, and decision trees were reported to have been used by a small number of offices. Researchers reported that the use of these new techniques occasioned scepticism and resistance in higher echelons of management. Officials also reported with some consistency that the regulatory process in particular has suffered from the fact that civilian agencies (in contrast to DoD) have lagged behind industry in developing a capability for technological forecasting.

The effect of bias from institutional and occupational affiliations of members of expert panels conducting technology assessments is an area in which behavioral research is needed. Such panels are sometimes used, especially for problem-oriented assessments focusing on societal problems (such as pollution, deviant behavior, or regional development) to which technology is either a contributing cause, a possible solution, or both. The use of a panel allows for representation of affected interests, and thus tends to increase awareness of political and institutional

feasibility and constraints; but it introduces a problem of bias and weighting in what is intended to be an objective and neutral evaluative process.

The appropriate role for public participation in assessment also needs further research and innovation. Conventional techniques such as public hearings necessarily occur at an advanced stage of planning or development and tend to crystallize opposition without significantly adding to the base of available information, without generating alternatives to the proposed action, and without providing for representation of the entire range of interests affected. Representation of interests implies the desirability of weighing interests in terms of numbers of people affected (and usually their political or economic power). Technology assessment aims at evaluating impacts in terms of desirable changes for society as a whole. These concerns may or may not be coincident in any particular case for any particular time period.

No innovative methods of incorporating public participations were discovered in this study. NASA has experimented with utilization conferences in planning space station programs, and FAA with consultative planning conferences. Both allow the expression of interests of potential users of systems, but do not provide input from other potentially affected parties, nor do these techniques seek out and identify unplanned consequences of agency actions.

Technology assessment "methodologies" advanced by a number of analysts are basically similar; they can be reduced to a structured analytical process involving several simple steps or tasks:

-- Definition of the subject of inquiry; description of the subject technology and its parameters; development of data base.

-- Description of alternative, supporting, and competitive technologies.

-- Development of state-of-society assumptions, for present and future time periods.

-- Identification of potential impacts.

-- Analysis of and evaluation of impacts in terms of
   (a) affected parties, systems, and processes,
   (b) probability of occurrence, direction, magnitude, and duration of induced changes.

-- Identification of possible action options.

-- Assessment and comparison of alternative action options.

On the basis of evidence from this study, it appears that technology assessment is most adequately performed by interdisciplinary teams using a variety of analytical techniques to accomplish the above tasks, augmented by on-site investigations of specific projects, and with the option of commissioning additional research if needed.

Analysis of a Sample of Technology Assessment Studies

Eighty-six offices in federal executive agencies provided a total of 97 examples of technology assessment and related studies

which were in progress in 1970-1971 or recently completed by the agency and its contractors. Since these studies were provided by agency officials they constitute neither a random sample nor an exhaustive list, but substantial evidence suggests that they made up the bulk of relevant research underway at that time. For purposes of analysis they were divided into six categories:

Wide-scope Assessments	- nine studies	- Criteria: Open-ended consideration of possible impacts in several categories; multidisciplinary teams; the intention to support and influence public decisionmaking; a level of funding sufficient for in-depth examination.
Partial Assessments	- forty studies	- Criteria: Consideration of pre-selected secondary consequences in one or more categories.
Problem-Oriented Assessments	- fourteen studies	- Criteria: Focus on a societal problem to which technology is a contributor or a possible solution.
Environmental Impact Statements	- fourteen studies	- Criteria: Required by the National Environmental Policy Act of 1969, and offered by an agency as an example of technology assessment. These are treated separately from other partial assessments.
Futures Studies	- seventeen studies	- Criteria: Dealt with trends affecting future utilization and development of technology -- supply/demand studies, technological forecasts, long range planning studies.
Miscellaneous	- three studies	- Criteria: Two technology assessment methodologies, one survey of technology assessments.

(a) Wide-Scope Technology Assessments

Initiation of broad policy research by an agency appears rare; the wide-scope technology assessments were almost all initiated by Congress or at a higher level of the Executive Office.

Research teams had an average of 4.5 disciplines per team. Physical scientists, economists, and social scientists were most frequently included. The study efforts took the form of interdisciplinary interaction of the team, using a variety of analytical techniques, and included field or on-site investigation in the case of specific projects. One study relied heavily on modeling and simulation, three provided for input from affected publics by hearings or surveys and one included a large program of origional research.

The average cost of these studies was $381,000. The mean cost was $149,000, there being a wide range of costs. Average elapsed time* was 16 months. This was somewhat shorter than the average elapsed time for partial assessments (wide-scope technology assessments generally constituted the entire workload of the research team during the time of the assignment, which was often not the case with partial assessments). The contention of many agency officials that wide-scope technology assessment was impractical because it would add greatly to the decisionmaking time, was not supported by the evidence of these studies.

There appeared to be a significant learning period in the

*From initiation of research to final report.

performance of wide-scope assessments; experience in performing wide-scope technology assessment would very likely shorten the average elapsed time for studies conducted by experienced teams or team members.

The most significant aspect of the wide-scope technology assessments was a greatly broadened or restructured analysis compared to that originally proposed for the study. This was a consequence of new information emerging in the course of the study. Unexpected potential impacts suggested new policy issues or alternative technological approaches for exploration.

Four kinds of recommendations were produced by these assessments:

-- New or altered research priorities,

-- Specific policy formulations,

-- Modification of accepted practices or projects,

-- Termination of projects.

Administrative changes or legislative actions appear to have resulted from all wide-scope assessments which had been available to decisionmakers for a period of months prior to this analysis. They ranged from "informal changes in practices" and "definite influence on the ordering of research priorities" to outright termination of two large projects.

(b) Narrow or Partial Technology Assessments

Partial technology assessments had usually been initiated by an agency, often as a result of unsolicited proposals. They were

performed or funded as part of the on-going substantive research effort or for purposes of agency programming and evaluation. Therefore they were less likely than wide-scope assessments to be directed toward a particular instance of decisionmaking or policy formulation.

Seventy-eight percent dealt with either one or two categories of impacts, most often economic impacts or enviromental impacts. [Environmental impact statements required under the National Environmental Policy Act are treated separately below.] Usually the impacts to be investigated were selected before the study began, i.e., the investigation was not open-ended. Economic impacts were analyzed in 55 percent of the partial assessments and environmental impacts in 38 percent. When social impacts were investigated, it was most often in terms of socio-economic changes such as migration of farm workers or "quality of life" (treated qualitatively).

The most frequently used mode of procedure was collection and analysis of existing data. Twenty-two percent of the studies included some input from affected publics, usually through questionnaires or interviews.

The research teams included an average of two disciplines per team. The most frequently used were economics and social sciences.

The average cost of partial assessments by university research groups was $85,000; the average for assessments by independent organizations was $139,000. No figures were available for those

performed in-house. University studies had an average cost per professional man/year expended which was little more than half of that for independent research groups, probably because graduate students were used in a professional capacity at low remuneration. No measure for comparison of quality was attempted in this study.

The average elapsed time for partial or narrow technology assessments was 18.5 months. For university efforts, average elapsed time was 13.5 months, for independent research organization studies it was 22.2 months.

(c) Problem-oriented Assessments

Three broad themes were found in this group of 14 studies: environmental and health problems, inadequate public services, and the probable need for federal regulation in new areas.

Problem-oriented assessments were initiated from outside the agency in nearly all cases, either by unsolicited proposals or as a result of requests from Congress, the Executive Office, or public or professional groups. This suggests that federal agencies rarely initiate exploratory investigation of societal problems.

Less than a third of the problem-oriented assessments appear to have resulted in traceable administrative or legislative action. These assessments began by conceptualizing a societal problem in which technology is a factor; to some extent they open up new areas and represent a preliminary evaluation of the

magnitude of a problem. Thus their influence may be slow to mature.

The average cost of the problem-oriented studies was $678,000. This is nearly twice the cost of wide-scope technology assessment. The relatively high cost is not fully explainable and may be spurious since cost figures were available for a relatively small number of studies. The average elapsed time was about the same as for partial assessments but teams were larger.

These studies were more multi-disciplinary than wide-scope assessments, with an average of 6.3 disciplines per team. Physical scientists, engineers, and economists were most often included. There were social scientists on only ten percent of the teams, although they were dealing with societal problems. One-third of problem-oriented assessments utilized panels of experts from outside the government, more than any other category of studies.

(d) Environmental Impact Statements

Environmental impact statements offered by agencies as examples of their assessment activity ranged from brief and cursory documents to elaborate research reports. All were classified as partial assessments since they dealt primarily with the physical environment but in some cases other impacts were discussed, such as effects on ethnic groups and communities.

One-half of the statements were the subject of considerable

public controversy. Two, and possibly a third, have been or will be the subject of law suits. Five of the fourteen were the subjects of public hearings. Thus these statements were far more likely than other partial assessments to enter the arena of public discussion.

Environmental impact statements probably cost less than other partial assessments. Since they were prepared within agencies, no cost figures were available. Officials estimated the costs as generally in the neighborhood of $15,000 to $50,000, on the basis of professional staff time. If the average level of effort is much lower, for example $10,000 or approximately 3 man/months, the annual cost (at a rate of 200 per month) is $24,000,000 or 600 man/years. This is probably a low figure, and moreover does not include the cost of multiple agency review.

Environmental impact statements are effective in forcing agencies to collect information necessary for technology assessment, in providing experience in multidisciplinary consideration of secondary consequences of actions and projects, and in providing a mechanism for public review of executive decisionmaking. The National Environmental Policy Act thus created and maintains a strong stimulus to the development of the technology assessment process in federal executive agencies.

(e) Futures Studies

Technology assessment necessitates and benefits from the further development of capability in futures research. Technology

assessments for governmental projects and programs must deal with potential or anticipated impacts. They must therefore consider the trends in technological invention and innovation, the possible changes in application and levels of utilization of technologies, and the possible social environments of the future within which the technology may be utilized.

Seventeen examples of the 97 collected were concerned primarily with trends influencing the future levels of utilization of technologies: they were supply/demand projections and extrapolations, technological forecasts, and long range planning studies looking to government-wide or agency programming needs.

Only one study attempted systematically to lay out alternative socio-political scenarios for the future. This study was concerned primarily not with the social utility of a technology but with planning agency strategy to insure acceptance of its programs; it was therefore promotional rather than assessment-oriented in its intent.

The three technological forecasts were initiated by agencies to help with planning research programs or future regulatory trends; they were performed by contractors. As has been noted, civilian agencies tend to lack capability in technological forecasting. These three studies cost an average of $140,000.

Supply and demand studies and long-range planning studies were intended to explore the need for new federal policies, or to support agency planning and programming. Three were requested

by Congress or the Executive Office, eleven were initiated by agency personnel. About half were performed in-house and half by contractors. Estimates of cost are difficult since so many were performed in-house. Four supply and demand studies for which estimates are available had an average estimated cost of $743,000, higher than that for any other category, but because of the small number this figure should be treated with caution.

A variety of analytical techniques was used in futures studies, including modeling and simulation, trend projection and extrapolation, surveys, Delphi techniques, economic analysis, and reliance on concensus of experts. A majority of studies relied on one or two of these methods, mathematical modeling and consensus of experts being the most frequently used. Only one study combined as many as four techniques.

Futures studies were not strongly multi-disciplinary; an average of 2.1 disciplines was used, engineering and economics being the most frequent. Most of the studies concentrated on one trend or subject area such as materials supply and demand, economic projections, or a pattern of technological development.

(f) Miscellaneous Studies

Two studies, one by the Water Resources Council and one by a contractor for OST, were attempts to formulate methodologies for assessment. Both codified approaches which are already in use and neither produced innovative techniques qualitatively different from present assessment procedures. Their usefulness lies in

providing systematic elucidation of the steps in analysis for researchers who have not had experience in technology assessment. The Water Resources study also included testing by a number of assessment teams of the proposed procedures, allowing for some experimentation in applying such procedures in a field situation. The variations which resulted suggest that the proposed assessment procedures will give results which are not strictly reproducible but which are comparable, useful, and defensible for decisionmakers.

The final study was a survey of current technological activity in the federal, state, local, institutional, and industrial sectors. These findings have not yet been released.

Gaps and Overlaps in Federal Technology Assessment

Technology assessment in federal executive agencies (in the civilian sector) is chiefly concerned with:

- -- technology related to basic human needs: food and fibre technology, housing technology, biomedical technology, water resource technology;
- -- technology critical to an industrial society: power technology, mineral resource technology, transportation and communications technology;
- -- technologies over which the federal government exercises a unique degree of control, largely because of astronomically high costs of research and development and their derivation from early military applications: space and nuclear power technology.

All of these technology assessment areas were covered by the present study with the exception of communications technology;

because of a series of reorganizations and institutional changes which were going on during the period of this study, communications was not well covered, except for the activity of the U.S. Postal Service. This area of federal technology assessment needs further attention and description.

In space and nuclear technology, NASA and AEC are in a unique position to control the development of technology from basic research to final application and utilization. These agencies therefore have a unique responsibility for, and opportunity for, technology assessment. Both have in the past largely ignored this responsibility and opportunity. Both agencies interpreted their mandate as chiefly promotional. AEC's statutory charter for regulatory activities was written narrowly; the narrow regulatory power was carried over to the development activities as a justification for non-attention to potential detrimental impacts of technological development. Under the pressure of judicial interpretation of the National Environmental Policy Act in the Calvert Cliffs case, AEC has publicly signified its intention of reconstituting its planning and evaluation procedures.

NASA has not only failed to develop a capability for technology assessment but has consistently taken an aggressively promotional stance toward the technology which after all provides its raison d'etre. Even the "benefits studies" which NASA sponsors or performs to display the spin-off of benefits from space activity

to the civilian sector, have taken second place to the glamour of manned space flight in NASA justification of its programs, and secondary benefits and costs have not been thoroughly assessed from the standpoint of determining the appropriate postion of space programs in national priorities.

Food and fibre technology assessment is centered in the Department of Agriculture. The Department produces a large volume of partial or narrow assessments of high quality, usually concerned with economic, and more recently environmental, impacts. It tends to avoid, ignore, or suppress assessments dealing with controversial or sensitive social changes. In other areas of technology, the lack of a single agency with clear responsibility for planning and evaluating technological developments over a wide area of concern contributes to a paucity of wide-scope assessment. In agriculture, however, the chief factors are fear of constituency pressure and congressional reaction, stemming from the incompatibility of two primary Departmental mandates: service to industrialized agriculture and protection of the small farmer.

Successive waves of agricultural technology development have generated serious social problems as well as world-wide benefits: the mechanization of farming, the development of chemical fertilizers and pesticides, and the change in ownership and management farming. These changes, and trends such as production of synthetic fibres, integration of chicken and livestock farming,

and the advent of frozen foods, occurred without comprehensive anticipatory assessment which might have allowed alleviation of resulting dislocations.

New developments for which assessment is urgently needed are biological pesticides, fabrication of structured proteins, integration of pork farming, automated underground irrigation, and controlled environment farming.

Housing technology is perhaps the least adequately assessed of major technologies. Federal involvement in this area was relatively late. The housing industry is highly fragmented, reflecting the fragmentation of the market and the lack of industrialization of the industry. Federal policies such as post-World War II veterans' mortgages have had a tremendous impact on urban-suburban development without benefit of anticipatory assessment. The Department of Housing and Urban Development views provision of additional housing and stabilization of costs as an urgent and critical problem and therefore puts emphasis on action programs rather than evaluative research. Continuation of current trends and preferences is assumed uncritically; there is little attention to new developments such as the movement toward communal living, delayed marriage, or smaller families. Some assessment of new materials and building procedures and industrialized housing is performed, but most evaluation is limited to performance characteristics. The view of housing needs as an impending crisis impedes the development of technology assessment in HUD.

Biomedical technology assessment is located in several federal agencies such as NIH, NIMH, and FDA. They all take a narrow view of technology assessment, concerning themselves almost entirely with the safety and efficacy to the individual recipient of drugs and medical devices, and to a lesser extent with costs of delivery and impact on medical training and practice. Consequences of biomedical technology to the public or society at large and consideration of wider public issues are not found to a great extent. In large part the explanation for lack of comprehensive assessment of biomedical technology is the prevailing American view of the private and privileged relationship between doctor and patient, which is rigorously defended by the medical profession against interference by public authorities.

Recent advances in biomedical technology such as new contraceptives, behavior modifying drugs and techniques, organ transplants, genetic manipulation and laboratory conception, have ethical and public policy implications which make broader technology an urgent need. The National Science Foundation through its RANN Program (Research Applied to National Needs), has initiated some assessments in this area. NIH and NIMH have sponsored some wide scope technology assessments, usually by scientific advisory committees, but these tend to avoid defining options or addressing policy issues.

FDA, like other regulatory agencies, has a statutory charter which gives it little discretionary authority in evaluating new

drugs and medical devices. Within this context FDA interprets its authority as narrowly as possible and tends to resist extensions of its responsibility.

Assessment of water resource projects and technology is highly important for a number of reasons:

-- Water resource projects constructed with federal funds may affect many communities in several states or impact on an entire region,

-- Water resource projects create both public and private goods,

-- They require large capital investments,

-- They need long lead-times for planning and construction, and

-- They make large-scale, permanent changes in the physical environment.

There is a long history of federal involvement in water resource projects and at least six federal agencies have major responsibilities.

The major constraints on assessment of water resource programs and projects are institutional (the need to maintain and expand agency programs and funding) and political (the actions of congressmen in seeking new projects for their districts, and in responding to constituency pressures in favor of maintaining the status quo).

In water resource technology assessment, however, the process has been broadened and improved over the last five years, largely to meet the demands posed by the environmental movement and the passage of the National Environmental Policy Act. There is also

reason to suppose that the improvement will continue. In 1965 the Congress created the Water Resources Council which provides a mechanism for integrating technology assessments performed in federal agencies. This interagency organization has developed and tested new standards and criteria for water resource projects planning and evaluation, to be used by all agencies. While these by no means guarantee wide-impact assessment, they take into some account not only environmental concerns but social and community impacts, and must realistically be appraised as a long step forward over previous criteria.

In 1968 Congress also established the National Water Commission to provide an independent assessment of alternative national water policies (including interbasin transfers, which the Water Resources Council was statutorially forbidden to consider) and their economic, social, environmental, and aesthetic consequences. Thus there is now both a mechanism for integrating agency technology assessments and a mechanism for providing an independent, non-agency, assessment of federal water resource projects, programs, and policies.

Power generation and transmission technology assessment is important for reasons similar to those operating in the field of water resource technology: a long history of federal involvement, multi-state or regional impacts, large capital investment, creation of public and private sector goods, significant changes imposed on the natural environment, and the existence of federal

regulatory responsibility. The private sector power industry is large and fragmented, and makes relatively little investment in research. Demand for power is rapidly rising, while at the same time it is becoming difficult to find acceptable sites for new power plants because of competitive demands for land near large bodies of water and because of the opposition of environmentalists. Application of nuclear technology to power generation and two problems associated with this innovation (thermal pollution and alleged radiation hazards) have contributed a new factor to severe problems of public acceptance.

A comprehensive technology assessment which considers all of the implications of a power-intensive society is urgently needed. Although technology assessments of power projects are performed by a number of agencies, and power generation is a factor in virtually all assessments of water resource projects, no one agency appears to have the motivation, resources, comprehensiveness, and responsibility to perform an overall assessment of this kind. Such an effort might well be sponsored by the Office of Emergency Preparedness, the Office of Science and Technology, or the National Science Foundation; this will probably require initiation by a mandate from the President or at the request of Congress.

More research is also needed to identify new sources of energy and to assess these alternatives. While the National Science Foundation's RANN Program has identified this as one of its

program areas, most attention has been given to hardware research and very little so far to assessment.

Mineral resource technology is also an area where federal responsibility is fragmented. Several offices within the Department of Interior are concerned with mineral resources located in the public domain (about one-third of the U.S. land area). The Bureau of Mines is responsible for mineral conservation, environmental problems, technological development, and health and safety regulation. Interior also has ecological and conservation responsibilities, and this dual mission creates internal pressures on departmental assessors. The petroleum and coal-mining industries are reported by some observers to be able to successfully bring pressure to bear on technology assessors; substantiation of this charge is beyond the scope of this study.

The amount of federal technology assessment activity in the area of mineral resource extraction is very low. This may reflect the relative importance of the states in this area, and the influence and power of the minerals industry vis-a-vis its regulators. In view of the size and economic power of these industries, the critical importance of mineral resources to the nation, and the environmental damage associated with many kinds of minerals extraction, more assessment is badly needed. This is particularly true of strip mining, off-shore drilling for petroleum and transmission of petroleum by sea and pipeline.

No single agency has cognizance over a single mineral or source

or over mineral extraction technology. An integrating mechanism for performing comprehensive technology assessment in the minerals extraction area is badly needed.

Transportation is a critical technology in the United States because of the very large land area, a geographically dispersed population, and a highly integrated industrialized economy. Although state and local policies have strong influence on transportation, the Interstate Commerce Clause has given the federal government a dominant role in transportation planning when it chooses to exercise that role. Highway, rail, air, water and urban mass transportation systems are affected differently by a welter of federal, state, and local policies and actions, such as taxes, user charges, safety regulation, capital charges, and planning activity. The result is a serious imbalance between modes, with nonproductive competition and uneconomic duplication of facilities and routes in some areas and a lack of any service in others.

Until 1966 federal planning, promotion, and regulation of transportation was also on a modal basis and dispersed between a number of agencies and commissions. In 1966 most promotional and safety regulation responsibilities were given to the newly created Department of Transportation. To a greater extent than is typical of other federal agencies, DOT officials profess to have responsibility for, interest in, and enthusiasm for the development of technology assessment capability. The establishment

of DOT is beginning to pay off in a strong effort to develop a planning, analysis, and evaluation process directed toward the creation of a national transportation system.

There are great obstacles to this development both internally and externally. Internally, the obstacles are a scarcity of funds for intermodal technology assessment, but even more importantly, the lack of coordination and cooperation between the constituent modal administrations and between the modal administrations and departmental planners. Externally, the obstacles are legislation which freezes inflexible relationships and competition, and the Highway Trust Fund which stabilizes past inequities.

The record of the Federal Aviation Administration in technology assessment is poor. Although it cooperated in a recent DOT-NASA civil aviation policy study which recommended greater attention to social science analysis in research, including social impact analysis, FAA continues to adopt a promotional stance toward new air systems and airports. FAA officials claim no responsibility for or interest in broadening their assessment process. A few FAA officials expect this attitude to change rapidly under pressure from DOT and Congress. The change is not yet apparent.

The Federal Highway Administration (FHWA) is displaying new interest in social and environmental impact studies, although it is not yet clear to what extent these will be integrated into decisionmaking. Highway transportation enjoys the benefits of

the Highway Trust Fund and the political protection of an allegedly powerful highway lobby. Assessment in FHWA has suffered from this political pressure and that which arises from State Highway Departments. But public controversy over urban segments of the Interstate and Defense Highway System begun in 1956 caused costly delays and forced some improvement in the planning process. The first congressional response, a requirement for comprehensive metropolitan planning written into the 1962 Highway Act, helped to rationalize regional highway planning but also created a gap between regional highway planners and local decisionmakers in which social impacts of highway location was largely ignored.

Public reaction to community disruption and massive relocation built up, and concern for the natural environment provided additional pressure. Congress added, in successive highway legislation during the 1960's, requirements for consideration of environmental and social impacts, new restrictions on relocation, and a requirement for consultation with other agencies. Under these pressures the FHWA which had sponsored some environmental and social impact studies (and collected large numbers of those done by states and universities) over a period of two decades, has greatly expanded this activity and provided additional guidelines for state and local planners.

The Federal Railroad Administration has begun preparations for several large wide impact technology assessments. Until 1971

FRA had little or no money for social impact research. With American railroads approaching a state of crisis, Congress has provided more funds and expanded FRA responsibilities in the areas of safety, efficiency, and environmental considerations. FRA is now planning technology assessments of relocation of rail facilities in rail-locked communities, of alternative safety devices for rail crossings, and of extension of the Alaska Railway. Plans for these studies are couched in technology assessment terminology and indicate a comprehensive study plan, but serious constraints of timing and funding.

Urban mass transit, until recently the step-child of federal transportation planning and funding, is now given "highest priority" by DOT. Until recently, the Urban Mass Transportation Administration regarded its primary mission as that of subsidizing local transit system development. While capital grants is still the primary thrust, there is now a policy that local projects should provide test cases for development of innovative approaches which have general applicability in other urban areas. UMTA displays something of the same crisis mentality shown by HUD in housing; since urban transit is an urgent need, emphasis is put on action programs, rather than on evaluation of social impacts of alternative solutions.

Prerequisites for Further Improvement of Governmental Technology Assessment

Futures Research must be upgraded and emphasized to allow improved forecasting of technological innovation and application, improved anticipation of possible impacts, and improved understanding of the alternative social contexts in which these trends may be experienced.

Current practices reinforce shortsightedness. When cumulative detrimental impacts reach serious proportions, or when the need for new technology or for technological solutions to societal problems is perceived as critical or urgent, action programs are emphasized. The evaluation of the potential social impacts of alternative solutions is downplayed or avoided lest it delay or interfere with immediate solutions. Urgent priorities and the demand for fast solutions constrain time, money, and personnel for foresight. More reliable and comprehensive forecasting techniques may help avoid such situations by anticipating problems before they become urgent and encourage alternative technological plans in advance of immediate needs. However, it appears that agencies will allocate sufficient funds and expertise to long-range planning and forecasting only if they receive a strong directive to do so from the Administration or from Congress.

Further major developments in technology assessment methodology will come from experience and experimentation to performing

technology assessment: the sponsoring of comprehensive technology assessments should not be contingent upon the general acceptance of systematic or elegant scientific methodologies. The development of an exhaustive and universally accepted list of social indicators, and the working out of quantifiable relationships between technological applications, impacts, and processes of social change is desirable. Development of technology assessment as an integral part of planning and evaluation of technological projects and programs can proceed without standardization of procedures if there is a strong and continuing demand from Congress or from the President through the Office of Management and Budget.

The demand for technology assessment from the agencies should be substantive rather than procedural. Institutionalization of technology assessment on the model of the filing of environmental impact statements is not desirable. It is likely that formal procedures such as the filing of technology assessment statements would quickly degenerate into a procedural requirement to be satisfied at the lowest possible level of effort, and by adding greatly to the workload of the agencies would absorb resources and time better spent on high priority projects and anticipatory, long-range assessments.

In some areas, particularly housing, biomedical, space, mass transportation, and mineral resource extraction technologies, immediate and significant increase in volume, as well as the

quality, of technology assessments is necessary. The pressing need for more housing and more urban mass transportation, the rapid development of biomedical science, and the uncritical attitudes and policies of NASA and of agencies promoting mineral resource development, have resulted in serious gaps in governmental technology assessment. These gaps can be corrected if Congress and the Office of Management and Budget provide both the requirement and the resources for improvement of the planning and evaluation process within existing agencies.

In other areas, interagency organizations are needed to collect, compare, weigh, and integrate technology assessments for the use of decisionmakers. For technologies such as power and chemicals (pesticides, fertilizers, and food additives), where a number of agencies share responsibilities, each agency has a narrow mission or a specialized constituency. Partial assessments are conducted by various agencies but none is balanced and comprehensive.

The report of the National Academy of Public Administration (A Technology Assessment System for the Executive Branch, 1970) recommended that the Council on Environmental Quality become the center for policy, monitoring, and review of technology assessment for the Executive Branch. This recommendation now appears ill-advised. The Council on Environmental Quality is within the Executive Office of the President. To expand its function to the extent necessary to monitor assessments from all agencies and to

improve the process substantively, would require resources and multidisciplinary personnel far in excess of what is appropriate for an office in that locus. As it presently operates within a narrower range of responsibility, the Council's work is largely procedural. Broadening of the substantive responsibility of agencies as a result of the National Environmental Policy Act has come, and probably will continue to come, not because of pressure from the Council so much as from public pressure acting through Congress and the courts.

A better alternative is the creation of a small staff for each major area of technology, following the model of the Water Resources Council. A professional staff not under the direction of any single agency could collect, compare, and evaluate technology assessments performed by all agencies impinging on the technology, and from other assessment entities in the private sector, and could also suggest and sponsor other assessments which are needed.

Finally, a source of independent assessments is needed. In all areas of federal involvement with technology, performance of objective comprehensive technology assessments is constrained by the demands of institutional protection. Agency performance is judged in terms of the volume of successful projects and programs and in terms of growth of appropriations and personnel. The success of programs and projects is generally judged in terms of planned or intentional performance rather than in terms of

second or third order effects which show up later and are sometimes difficult to relate to specific decisions or programs. These factors make inevitable some agency bias. Therefore a source of independent assessments should also be provided.

This function is best served by an organization which has no responsibility either for the projects and programs being assessed, or for avoiding or correcting their possible consequences. An agency which funds research but which has no line responsibility is in the most appropriate situation to sponsor independent technology assessments and to make these available to the Executive, the Legislature, and the public. Technology assessments sponsored in this way can cut across agency missions and can be consucted at any stage of development, including the critical anticipatory stage. They can potentially be given maximum exposure for all elements of the public decision-making process.

In order to achieve these two advantages fully, however, three things are necessary. The first is a system of publication and dissemination of assessment results so they reach the public and decisionmakers quickly, and in a readable and usable form. Most research-funding agencies have not yet developed such dissemination systems. The second necessity is for congressional funding which is both ample and sustained. The third requisite is that the management of the sponsoring agency adopt and maintain an attitude toward assessment needs which is fiercely independent, daring, and farsighted.

RECOMMENDATIONS

I. More attention to anticipatory assessment and long-range planning must be demanded from all agencies. Congress and the Executive Office (especially OMB) should provide additional resources and strong directives for expanded futures research, including technological forecasting, technology assessment, and social forecasting.

II. Emphasis on performance of technology assessment should not wait upon the development and acceptance of systematic methodology. Federal executive agencies are now in a position to perform and use technology assessment, and further methodological development should and will come from experience and experimentation in conducting technology assessment.

III. Strong and continuing pressure from Congress and from the Office of Management and Budget will be necessary to overcome built-in institutional inertia and ensure that federal agencies continue to improve and broaden the planning and evaluative procedures for technological projects. OMB should take steps to provide this pressure.

IV. The demands made by the Office of Management and Budget and the Congress should be substantive but not procedural. Formal requirements for technology assessment statements

on the modal of environmental impact statements are not desirable.

V. Pressure for a greatly expanded volume of technology assessment is especially needed in housing technology, biomedical technology, space technology, mass transportation technology, and mineral resource extraction technology.

VI. New organizations with small professional staffs should be provided for certain major areas of technology where many federal agencies have partial, overlapping, or conflicting responsibilities, such as power generation, chemicals, and biomedical technology. The function of these offices, following the model of the Water Resources Council, would be to collect, compare, weigh, and integrate technology assessments from the public and private sectors.

VII. A source of independent technology assessments should be provided. Maximum objectivity and usefulness to public decisionmakers can be achieved if assessments are sponsored by a federal entity having no responsibility for the project or program to be assessed, and are conducted by independent research organizations or university research groups.

VIII. An agency which funds research but which has no line responsibility can best provide this source of independent assessments. Such agency must develop a system for

publication and dissemination of assessment results to decisionmakers and to the public in a speedy and usable form. Funding for this agency must be ample and sustained.

IX. An immediate research effort should be undertaken to identify possible future innovations and inventions which need assessment. The National Science Foundation should sponsor a national survey of industry, research centers and government sources, aimed at identifying technology assessments which should be undertaken at once (some of which have been pinpointed through the present study). These would include recent and imminent developments in the experimental sciences, and also areas in which dramatic changes in level of application or utilization of existing technology are occurring or are likely to occur. The study should also include a large-scale effort in technological forecasting to anticipate developmental trends which have not yet become apparent. The fruitful approach to societal problems arising from technology is not alleviation but anticipation and avoidance.